Mid-Project Report

for

"LEDs: Energy Savings and Replicability in MN Livestock Facilities"



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Acknowledgements/Project Participants

This project was supported by a Conservation Applied Research and Development (CARD) Grant from the **Minnesota Department of Commerce, Division of Energy Resources**. The purpose of the CARD Grant Program is to identify new technologies, strategies and programs that utilities might implement to help achieve Minnesota's annual energy conservation goal of 1.5 percent.

The Minnesota Project is a St. Paul based non-profit organization whose mission is to champion the sustainable and equitable distribution of energy and food in communities across Minnesota. The Minnesota Project is the primary organization leading the implementation of this project.

Once Innovations is a Plymouth, MN based company whose mission is to improve the lives and profitability of farmers and enhance the welfare of poultry and livestock with energy-saving, cost effective technologies and lighting products. This project was also supported by Once Innovations' contribution of time and resources.

Introduction

Rural electric cooperatives are searching for opportunities to access efficiency improvements that will help them continue their work toward meeting their Conservation Improvement Program (CIP) goals. Poultry production facilities, substantial customers for many rural electric cooperatives, have limited opportunities for electric energy efficiency improvements. Minnesota is the number one turkey production state in the United States. In 2008, the state raised approximately 48 million turkeys. The state raised an additional 44.9 million broiler chickens in 2008, along with approximately 14.1 million non-broiler chickens (egg laying and/or dual purpose chickens).

Lighting is a major energy use of the poultry industry. The Energy Independence and Security Act of 2007 will require the implementation of high performing lighting technologies across all industries, while less efficient lighting technologies are phased out. As such, Minnesota's poultry producers will require alternative options to incandescent lamps to maintain safe and productive growing conditions in their facilities. While compact florescent lamps (CFLs) present a significant energy savings improvement over incandescents, questions remain surrounding CFLs' durability in harsh barn conditions. Additionally, some industry stakeholders have expressed hesitation towards installing CFL lamps in poultry production facilities, with the potential of a broken bulb releasing mercury into the birds' feeding areas.

LED technology is an additional alternative to incandescent lamps, but the cost of converting to an LED lighting system can be relatively high. As such, producers have been reluctant to make such a substantial investment to their production system until it has been demonstrated that LED technology is dependable, cost-effective, and commercially replicable.

With support from a Conservation Applied Research and Development (CARD) Grant from the Division of Energy Resources at The Minnesota Department of Commerce, The Minnesota Project has launched a pilot project to measure the energy savings, performance and durability of LED lighting technologies designed specifically for poultry facilities. Through this pilot project, The Minnesota Project is installing LED lamps in poultry production facilities across Minnesota. For their participation in the study, the producers are receiving a cost share on the lamps from the Minnesota Project, as well as a discount from project partner, Once Innovations, Inc.

The project team will document the energy use and performance of these newly-installed LED lighting systems in barns across the state to determine energy savings potential and to evaluate the dependability of LED technology for both producers and electric utilities. The data gathered through this study will be used to help determine the potential for future inclusion in utility Conservation Improvement Programs (CIPs).

Project Goals

- Demonstrate the effectiveness of an energy efficient, early commercial technology to rural electric cooperatives struggling to find additional energy saving opportunities in their service territories.
- Investigate the cost-effectiveness of the technology and identify information necessary to develop a scalable CIP program.
- Provide an on-the-ground, observable example of a lighting technology designed specifically for the rigors of agricultural environments so commonly found in Minnesota.
- Establish the ability of this technology to maintain, or even increase, productivity while meeting and exceeding all applicable efficiency standards.
- Record and report the demonstrated energy savings resulting from this pilot project.

Project Partners

The Minnesota Project

The Minnesota Project¹ is a non-profit organization based in St. Paul, MN. The Minnesota Project's mission is to promote the sustainable production and equitable distribution of energy and food in communities across Minnesota. In addition to its Clean Energy program (responsible for this project), The Minnesota Project is also involved in local foods and sustainable agriculture issues.

Most recently, The Minnesota Project's Clean Energy Program has been working to promote energy efficiency on farms across Minnesota. Toward this goal, The Minnesota Project has created myriad energy efficiency educational documents, held multiple energy efficiency 'townhall' meetings, and administered a farm energy auditor training program. This pilot project continues this work into one of Minnesota's largest agricultural communities.

The Minnesota Project designed the pilot project and is responsible for administering the project funding, as well as reporting on the project results.

Once Innovations

The Minnesota Project is working with Once Innovations, Inc. ² of Plymouth, MN as the primary technology provider and lighting system consultant. Once Innovations manufactures LED lamps specially designed to allow for adjustments to the color temperature and light intensity at different times in the poultry production cycle. Their lighting products were also designed to withstand the oftentimes humid and dusty conditions found in poultry barns.

For this project, Once Innovations has been primarily responsible for securing suitable project participants (poultry producers). Once Innovations has cultivated a significant network of

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¹ www.mnproject.org

² www.onceinnovations.com

contacts within the poultry industry since its inception in 2008 and therefore has a solid understanding of the primary stakeholders who might be most interested in participating in this project.

Industry Overview

The poultry production industry, with all its differing operations and producers, is a very unique agricultural industry. The "poultry" industry in Minnesota, as a whole, includes producers from the turkey growing industry, the chicken growing industry, and the egg laying industry.³ Each of these industries (turkey, chicken, and egg layers), has many similar production needs, but also require some very individualized lighting options. So, while the poultry industry in Minnesota is generally quite large, it quickly segments itself into a number of smaller groups of producers with individual production needs, discussed below.

Importance of Lighting Systems in Poultry Operations

A well-designed lighting system allows poultry to live in an optimum growing environment, free from crowding. A well-lit facility also allows farm workers to carry out work in the facility in an efficient manner. In addition, a well-designed lighting system presents opportunity for production increases related to a bird's biological response to various changes in color, intensity and length of lighting exposure. For example, decreasing the length of light in a day – as naturally happens in the autumn and winter – changes circadian rhythms and stimulates an adolescent bird to sexual maturity.

While two of the three important prongs of poultry lighting - light intensity and light exposure - can be accomplished by most types of lighting systems, LED lamps present additional opportunity to influence the third prong of poultry lighting systems: color. Indeed, significant academic research exists noting the potential for production gains related to exposing poultry to various colors of light throughout their growing cycle. Research has shown that red and green hues increase growth rate at early ages, while blue hues increase growth rate at later ages and decrease incidences of cannibalism. Using many small, light emitting diodes (LED) in one of its 100w incandescent equivalent lamps, Once Innovation's LED lamps are designed to dim not

³ The unique blend of shared needs and resources versus industry specific production requirements is exemplified through the industry's trade association setup in the midwest. The Midwest Poultry Federation is a "poultry industry" trade association located in Minnesota that brings together each of these varying industries at its annual Midwest Poultry Federation Convention. The myriad activities taking place at this event can be confusing for an outsider. The Minnesota Turkey Growers Association and the (Chicken) Broiler and Egg Ass'n of MN each hold their own annual meetings, but share a trade show that fills St. Paul's Rivercentre. For good measure, the Minnesota Turkey Growers Association shares office space and a website with the (still completely separate) Broiler and Egg Association of Minnesota.

⁴ Birds generally 'flock' to areas of light. Where 'spotlighting' exists in barns due to uneven lighting conditions, birds will group in the most lighted areas, and often overcrowd one another.

⁵ See, for example: Prayitno, Phillips, Stokes. "The effects of color and intensity of light on behavior and leg disorders in broiler chickens. Poult Sci. 1997 Dec; 76(12): 1674-81. See Also: Cao, Liu, Wang, Xie, Jia, Chen. "Green and Blue Monochromatic Lights Promote Growth and Development of Broilers Via Stimulating Testosterone Secretion and Myofiber Growth." J. Appl. Poult. Res. Summer 2008. Vol. 17, no. 2, 211-218.

only the intensity of their light output, but also their light color, placing them in a position to take advantage of the potential "color dimming" production gains.

The table below outlines the products Once Innovations has developed and the poultry production application to which they are best suited.⁶

Table 1: Once Innovations Lamp Types.

| Poultry Type | Once Innovations Lamps | Energy Use/Light Output ⁷ | |
|------------------|--------------------------------------|--------------------------------------|--|
| | AgriShift® PL (Primary Light Source) | 12w/100w incandescent | |
| | Agnomic FL (Filliary Light Source) | equivalent | |
| Turkey | AgriShift® FL (Feed Pan Light) | 3w/25w incandescent | |
| | Agnomitto FL (Feed Fan Light) | equivalent | |
| | AgriShift® PL (Primary Light Source) | 12w/100w incandescent | |
| | Agnosime PL (Philiary Light Source) | equivalent | |
| Chicken Broilers | AgriShift® FL (Feed Pan Light) | 3w/25w incandescent | |
| | Agrisintto PL (Peed Fan Light) | equivalent | |
| | AgriShift® PLE Dim-to-Red® (Primary | 12w/75w incandescent | |
| Egg Layers | Light Source) | equivalent | |
| | AgriShift® EL (Cage Lighting) | 3w/25w incandescent | |
| | Agrishitte EL (Cage Lighting) | equivalent | |

⁶ In addition to the table below, more technical information, including voltage, frequency, power factor, total harmonic distortion, luminous flux, and ratings is available on Once Innovations' product page at: http://www.onceinnovations.com/agriculture.html.

⁷ Because Once Innovations' LED lamps produce light spanning a wide color spectrum (unlike most high pressure sodium or incandescent lamps which only produce light in a very small section of the color spectrum), the lamps actually produce light observable by the eye of a bird, though not of a human. As an example, Once Innovations' Agrishift PL produces a luminous flux of 840 observable lumens for poultry and 530 lumens for humans. This message is important to convey to farmers. That is, a Once Innovation lamp is producing sufficient amounts of light, some of which is not observable to their (human) eye.

Turkey Production in Minnesota

Minnesota is ranked number one in the country for turkey production. The state is home to about 250 turkey farmers who operate about 600 different turkey farms. The average turkey farmer in Minnesota raises three flocks per year, with an average flock size of about 15,000 birds. Minnesota is home to the world's largest turkey hatchery company, Willmar Poultry, and the second largest turkey processing company in the U.S, Jennie-O Turkey. A majority of turkey production in Minnesota takes place in the central part of the state.

Turkey producers typically have at least two different types of barns on their farms: a "brooder" barn used for growing young poultry in a warmer, more secure environment, and a "grow-out," or "finishing," barn used for growing the poultry to their desired finish weights. This separation of young from old cuts down on disease transfer and injuries from pecking. Also, hens and toms are separated by barn to allow the farmer to meet their differing metabolisms, growth rates and feed requirements.

At about a day old, "poults" (just hatched birds) are transported to a brooder barn within 24 hours of being removed from the hatchery. These brooder barns are climate-controlled and are kept warm with the temperature gradually lowered as their down is replaced with feathers. As the following table illustrates, the turkeys brood for up to 6 weeks, after which they are moved to the grow-out barn and are "finished" for several more weeks, the length of time depending on the sex and type of turkey.

| Type of Poultry | Time in Brood | Time in Grow-Out | Market Weight ⁸ |
|-------------------|---------------|------------------|----------------------------|
| Broilers (female) | Up to 6 weeks | 10-12 weeks | 8-12 lbs. |
| Hens (female) | Up to 6 weeks | 11-15 weeks | 12 to 19 lbs. |
| Toms (male) | Up to 6 weeks | 12-19 weeks | 20-40 lbs. |
| | | (up to 25 weeks) | |

Table 2: Turkey Grow Out Periods.

Depending on the type of turkeys raised, a farmer can grow between three to seven flocks a year. The time between flocks might be one to two weeks. In between each, the barn is totally cleaned and disinfected to help prevent the spread of disease from one flock to another. Any repairs to the facilities, including lighting retrofits, would also most often be made at this time.

A typical lighting program for turkeys can vary based on the sex and type of bird, as well as what phase of its growing cycle it is in. The table below gives a general picture of what a lighting program might look like for a turkey operation, with a more or less consistent lighting schedule

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⁸ The weight of a finished tom, or any turkey, will vary depending on the producer's desires. Some turkeys are grown to be sold as whole birds (the Thanksgiving turkey) while others are grown to be processed for other uses (sandwich meat, etc.).

used when birds are moved to the grow-out (or, finishing) barn. Some farmers choose to employ differing lighting cycles such as an intermittent schedule or a "night light" in the last few weeks of grow-out.

Table 3: Typical Turkey Lighting Programs.

| Stage of Poultry | Age | Minimum Light | Photoperiod |
|------------------|---------------|----------------|-----------------|
| | | (Foot Candles) | (Light per Day) |
| Brooder (Poults, | 0-3 days | 9-10 fc | 22-24 hours |
| both sexes) | 3-9 days | 3-5 fc | 16-22 hours |
| Grow out (Hens) | 9 days and on | 1-3 fc | 16 hours |
| Grow out (Toms) | 9 days and on | 1-3 fc | 16 hours |

Chicken Production in Minnesota

Minnesota is ranked eighteenth in the country for broiler chicken production and is home to Gold'n Plump Poultry, which is ranked nineteenth in the country for broiler chicken production. As with turkeys, much of the broiler chicken production in Minnesota is located in the central area of the state.

Unlike turkey producers, chicken producers will not usually have two types of barns on their farms. However, it is typical to utilize brooding rings that bring the chicks close to a heat source, food and water in the first week or two of their lives. Beyond this, the brooder rings are removed and the adolescent chickens are given full access to the barn space. Often enough, the chicks are not separated by sex, though such separation can allow a farmer to more accurately address the male and female birds' differing feed needs and growth rates. Chickens reach their full maturity and weight much faster than turkeys. Therefore, the grow-out period is much shorter. Chickens are typically grown to 7 weeks old and then processed. Some are even processed at 4 weeks and marketed as Cornish hens.

Table 4: Chicken Grow Out Periods.

| Type of Poultry | Time in Brood | Time in Grow-Out | End Market Weight | |
|-----------------|---------------|------------------|-------------------|--|
| Broilers | 10-14 days | 2 to 7 weeks | ~5 lbs. | |

After a flock is processed, the barn is cleaned thoroughly and disinfected to minimize diseases and harm to the birds. It's not uncommon to receive the next flock within a week to two weeks of the last one, though this time period can vary depending on market prices, grow-out rates, and

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⁹ Of course, each producer involved in this project has demonstrated a preference to adjust these typical lighting schedules based on their own experience. Each of these producers has shown slightly different schemes from one another.

when a producer decides to process a finished flock. All in all, a producer might raise six to eight flocks per year.

A typical lighting schedule for broiler chickens does not vary drastically from turkey production, although the specific program that a farmer uses can differ depending on breed and grow-out times. Generally speaking, long periods of light are first provided to facilitate chick growth and activity, after which lighting hours are tapered off during the mid-point growing period. Finally, the photo period is increased again just before processing. As with turkey production, some producers utilize intermittent lighting schedules or a lighting plan that amounts to something other than a 24 hour cycle, called ahemeral lighting. The table below offers a general lighting plan.

Table 5: Typical Chicken Lighting Programs.

| Type Stage of Poultry | Age | Minimum Light (Foot Candles) | Photo Period (Light per Day) |
|-----------------------|-----------------------------------|---------------------------------|------------------------------|
| | 0 to 3 days | 2-3 fc | 22-24 hours |
| Broilers | 3 days to 7 weeks | 0.5-1 fc | |
| | (4 weeks for early finish) | 0.3-1 10 | 12-20 hours |
| | Or, 4-7 weeks (8 to 3 days before | 0.5-1 fc | |
| | processing) | 0.3-1 10 | 20-24 hours |

Egg Production in Minnesota

Minnesota is ranked seventh in the country for egg production. Notable egg production companies in Minnesota include Sparboe Farms Company, Michael Foods, Rembrandt Foods, Land 'O' Lakes, Cargill, and Mendelson Egg Company.

Pullets, the young female chicks that become laying hens, are delivered to the farm within one or two days of hatching. From there, pullets are either raised in cages or in a pullet house until they are moved to a laying house at 17-18 weeks of age, once they have attained a healthy body weight to support egg production. In the laying house, each hen is kept in a laying cage (unless "free-ranged").

When a flock of hens first enters the laying house, the rate of hens laying ¹⁰ will be about 10-20% at 18 to 22 weeks of age. This quickly increases to 90% or more at about 30 to 32 weeks of age. After this peak, egg production diminishes to about 50% at 60 to 70 weeks, at which time the producer might choose to molt the flock in order to boost its egg laying rates. The laying rate ceases during molting. Approximately 10 weeks later the flock would be back at a 50% laying rate increasing ultimately to 80%. This new peak is short-lived, though, and the flock drops back to 50% production at 100 to 110 weeks, at which point it could be molted once more. Rather than molting the flock at any of the above mentioned stages, the producer may choose to retire the

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 $^{^{\}rm 10}$ That is, hens actually laying eggs, as opposed to those who are not.

flock to a spent hen facility to be processed. Afterwards the laying house is cleaned and sanitized and the producer readies for a new batch of layers. The turnaround time between flocks is similar as with broiler and turkey production, if less frequent given the longer lifespan of the birds.

Table 6: Typical egg laying production cycle.

| Type of Poultry | Time in Pullet House | Time in Laying House |
|-----------------------|-----------------------|-------------------------------|
| Pullets/Layers (Hens) | Up to 17-18 weeks old | 18-80 weeks old; |
| | | up to 100-130 weeks if molted |

The lighting program for egg layers is very dependent on the breed of layer selected, particularly in the pullet stage. As with poultry raised for meat, the chicks are exposed to long periods of light in the beginning to encourage feeding and growth. With pullets, this light is incrementally decreased week by week until pullets are about 16 weeks old and the photoperiod is again increased to cue sexual maturation in the chickens. At about 18 weeks old, when the pullets (now hens) are moved to the laying house, the light is stepped up bit by bit to a more consistent schedule of 15 to 16 hours of light per day, which will continue through the egg production cycle. In the case of molting, a producer can induce the flock to molt by decreasing the amount of light and restricting food for a set "fast period," thus mimicking winter. Then the photoperiod length is increased again (as with spring) and the birds will start laying once more. The table below gives a general idea of a lighting program for egg laying operations.

Table 7: Typical egg laying lighting program.

| Stage of Poultry | Age (Weeks) | Minimum Light | Photoperiod |
|------------------|-----------------------|----------------|-----------------------------|
| | | (Foot Candles) | (Light per Day) |
| | 0-2 weeks | 1-3 fc | 16-22 hours, decreasing by |
| | | | increments each week |
| D 11 . | 2-14 weeks | 1-3 fc | 8-16 hours, decreasing by |
| Pullets | | | increments each week |
| | 15-17 weeks | 1-3 fc | 8-12.5 hours, lowest |
| | | | photoperiod |
| | 18-24 weeks | 0.5-2 fc | 8-16 hours, increasing by |
| Layers | | | increments each week |
| | 24 weeks and onward | 0.5-2 fc | 15-16 hours |
| | 70-80 weeks and 100- | 0.5-2 fc | 8-12.5 hours, decreasing to |
| Molting Layers | 110 weeks | | lowest photoperiod and back |
| | 80-100 weeks and 110- | 0.5-2 fc | 15-16 hours |
| | 130 weeks | | |

Current Participants.

Project Start

The project team plans to install LED lighting systems in at least 10 poultry facilities across Minnesota. With these numbers in mind, the project was slated to begin in mid to late July 2011. However, the Minnesota State Legislature's failure to pass an adequate budget bill throughout June caused a statewide government shutdown through most of July. This unforeseen circumstance caused the project team to miss an optimum lighting installation period preceding the poultry production cycle leading up to Thanksgiving. Since that time, the pilot team has continued working toward its installation goal.

At the time of this report, the project team has installed lighting at the facilities of five producers, spanning nine barns. The project team is in the process of finalizing lighting plans with two additional producers and would like to identify three additional producers thereafter.

Current Participants

The table below outlines the five producers currently involved in the project. Some of the producers involved in the project have installed lighting in more than one of their barns. For purposes of this project however, the project will combine the barns for each producer into one "site". This will minimize confusion and help calculate energy savings. Another table, below, outlines specifics of each producer's past and current lighting system. More data, concerning each producer's lighting program, and opinions of the technology, will be included in the final report.

Table 8: Current Project Participants

| Site | Production | Barn Type | <u>Utility</u> | <u>Utility Rebate?</u> |
|---------------------|-------------------|-------------|---------------------------------------|-----------------------------------|
| Flying C Farms | Turkey | Grow/Finish | Xcel Energy | No |
| Zimmerman Farms | Turkey | Grow/Finish | Steele-Waseca Cooperative Electric | Yes; Covered Costs of Rewiring |
| Lakewood Turkeys | Turkey | Grow/Finish | Meeker County Electric Cooperative | No |
| Dennis Buysse | Turkey | Brood | MN Valley Electric Co-op | No |
| Gorans Bros. | Turkey | Grow/Finish | Kandiyohi Power Cooperative | No |

Flying C Farms

Flying C Farms was the first producer to sign up for the pilot project. Each of Flying C's two finishing barns are participating in the pilot project. The finishing barns are approximately 60 feet wide by 500 feet long and each hold approximately 15,000 birds at one time. Though specifics of their lighting program are confidential, Flying C uses the lamps in their barn for approximately 6888 hours per year.

Between the two barns, the pilot project has installed approximately 290 LED lamps at Flying C's facilities. In each of the barns, the LED lamps replaced existing high pressure sodium (HPS) lamps. The installation of the lamps was handled by Mike Christianson, of Flying C, and his brother in law, who is a professional electrician. The project also required some rewiring, which was also handled by Mike and his brother-in-law. Flying C also installed a new dimmer that would most fully take advantage of the dimming capability of the Once Innovations lamps.

Zimmerman Farms

Zimmerman Farms was the second producer to sign up for the pilot project. John Zimmerman's poultry operation consists of six barns: two brooding barns and four finishing barns. Zimmerman had been testing a number of Once Innovation's lamps in one barn before the pilot project was developed and was interested in participating in this project as well.

In total, this project (excluding previous LED installations) has installed approximately 204 lamps at Zimmerman farms and is collecting data from each of Zimmerman's four finishing barns. Each of Zimmerman's finishing barns varies in size and bird capacity. Some rewiring was required for the installation of the lamps at Zimmerman farms, as well. The LED lamps replaced primarily incandescent lamps. While the incandescent lamps could have been replaced 1 for 1, Zimmerman utilized this time of expansive upgrading to also replace his wiring and fixtures, which were old and deteriorating. Zimmerman and his staff rewired each of the barns with new conduit wiring and fixtures.

Lakewood Turkeys

Lakewood Turkeys currently has LED lamps in one of its finishing barns, which is approximately 76' x 416' and generally houses about 21,000 birds. Lakewood had been converting its traditional incandescent and HPS lamps to CFLs when it first learned of Once Innovations. At that time, and prior to its participation in this pilot project, Lakewood decided to replace some of its CFLs with LED lamps. Thereafter, Lakewood was interesting in increasing its light levels in this barn. After hearing of the pilot project, Lakewood decided to install more lamps in the barn that had first housed CFLs. This barn went from having 58 CFLs, to 58 LEDs to its current setup of 110 LED lamps. Moving from CFLs to LEDs allowed Lakewood Turkeys a simple 1 for 1 replacement process.

Dennis Buysse

Dennis Buysse is the project's first producer to install LED lamps in a brood barn. Originally, Buysse's brood barn consisted of 72 CFL lamps. However, in mid-2011, Buysse's brood barn burned down and needed to be rebuilt. After learning of the pilot project from a nearby electric cooperative manager, Buysse decided to install half CFL, half LED in the reconstructed brood barn. As such, Buysse's brood barn now has alternating CFL and LED lamps, consisting of a total of 36 CFLs and 36 LEDs. The brood barn is approximately 80' x 208' and houses 35 to 40 thousand birds. New construction allowed Buysse to put each type of lamp on a different switch, and he now uses each of these lamp types to vary his lighting program.

Gorans Brothers Turkey

Finally, Gorans Brothers turkeys are currently testing LED lamps in one of their finishing barns in central Minnesota. The barns are approximately 76' x 400' and contain approximately 15,000 turkeys each. Gorans Brothers replaced CFLs in their finishing barn, allowing for 1 for 1 screwin replacement. This labor was handled by Gorans Brothers staff.

Mid-Project Progress/Analysis

Current Results

Table 9: Participant lighting/energy use changes.

| Site | Lighting Hours/yr. | LED Lamp | Replacing | Lighting Energy Use (kW) | | Energy Savings | |
|-----------|--------------------|-------------------------|---|-----------------------------|-------|----------------|----------|
| | | #/Lamp Type | #/Lamp Type | Pre: | Post: | kW | kWh/yr. |
| Flying C* | 5110** | 280/12w Agrishift PL | 40/150w HPS (+40w Elec. Ballasts) | 7.6 | 3.36 | 4.24 | 21666.4 |
| Zimmerman | 4380 | 207/12w Agrishift PL | 204/100w Incan. | 20.4 | 2.484 | 17.916 | 78472.08 |
| Lakewood* | 4454 | 110/12w Agrishift PL | 58/23w CFL | 1.334 | 1.32 | .014 | 62.36 |
| Buysse | 8322 | 36/12w Agrishift PL | 36/26w CFL | .936 | .432 | .504 | 4194.28 |
| Gorans | 6132 | 39/12w Agrishift PL | 39/23w CFL | .897 | .468 | .429 | 2630.63 |

^{*}Both Flying C and Lakewood Turkeys took this project opportunity to not only retrofit their old lighting but increase the amount of lights in their barns with an eye toward a better growing environment. Even after increasing the amount of lighting, each producer realized some energy savings.

Methodology for Energy Savings

Energy Savings

Kilowatt (kW) energy savings were calculated by subtracting the total energy use of the new LED lighting system from the energy use of the farmer's previous lighting system. Energy use of both the new and old lighting systems was calculated by multiplying the number of lamps in a given facility by that lamp's stated wattage. Each producer was surveyed about the type and number of lamps in their facility before and after the LED lamp install.

For those facilities that replaced HPS (150 watt), the study added an additional 40 watts per lamp to account for the load required by the electronic ballasts necessary for these HPS lamps.

Kilowatt hours savings were calculated by multiplying the approximated kilowatts saved from the LED installation by the approximate number of hours the lighting systems operate per year. Each producer has their own unique lighting program, ranging from 12 hour blocks of continuous lighting to repeating "4 hours on/1 hour off"-type schedules. In total, most producers typically operate their lights between 12 and 18 hours per day, every day, with some slight changes between the summer and winter months. Each producer was surveyed regarding their own lighting system, and total lighting hours were included in the table above, though specific

^{**}Flying C actually decreased their lighting hours per year upon the installation of the LED lamps, moving from 6078 hours per year down to 5110 hours per year. However, since this was done only in part because of the new lamps, the lower number is used here, to keep savings estimates conservative and consistent.

schedules, including dimming schedules, discussed below, were excluded to retain some producer privacy.

Lessons Learned, so far.

As the installation and early stages of technology monitoring have progressed, the project team has managed to gather some useful insights surrounding the primary producer motivations for installing LED technology. Each of these insights is discussed below, in no particular order. These insights will be re-examined as the project moves forward, and additional thoughts will be added to the final report.

Farmers value the importance of potential energy savings.

While it could likely go without saying, farmers are well aware of their budgets for energy use in their poultry operations. Each of the producers involved in this pilot project are lighting their barns (at 100% light intensity) anywhere from 12 to 18 hours per day. ¹¹ As such, decreases in energy use through efficient lighting can quickly realize significant value. Speaking with farmers has revealed that although significant light can be harvested from the sun during daytime hours, producers will nonetheless supplement natural day-lighting with their lamps, to ensure a minimum, uniform light level across all seasons and weather patterns.

Lighting is an important production decision.

In addition to energy savings, a common theme emerging from early project conversations revolved around lighting programs' importance to a bird's growing cycle. From a pure production standpoint, farmers are constantly attempting to maximize their livestock's feed conversion efficiency. Simply put, feed conversion efficiency is a measure of the amount of food a bird eats compared to amount of weight it puts on. Though all producers have exhibited a knowledge of the baseline lighting conditions necessary for maintaining a consistent production efficiency, it remains to be seen how well a 'production increase' message will resonate with producers as an implementation motivator. Some producers appear to be aggressively pursuing this selling point of the technology, while others seem to view it as more of a 'wait and see' benefit. 12

Even, uniform lighting is appealing to producers.

A number of the producers involved in this study have also commented on the change in quality light resulting from the switch from larger HPS lamps to smaller LED lamps. Though the producers expressed some reluctance to rewire barns in order to accommodate the new technology, they also noted the benefit of having an even, more uniform light spread across their

¹¹ Some, though not all of these producers utilize various forms of 'night-lighting' in their barns as well. These night-lighting programs range from dimming the lamps to 10% capacity, to turning off all lamps except for 5 or 6. ¹² This 'wait and see' approach is likely well informed. As in many industries, farmers are presented with a myriad of 'next big thing' opportunities from eager sales people. As such, they've become accustomed to taking a more measured approach to the introduction new technologies (dimmable, color changing LEDs) that modify a fairly conventional part of their operation (lighting).

barn. In pre-installation light measurements, our project team often found lighting "hot-spots" of up to 5.5 footcandles directly under old, HPS lamps and "valleys" of .8 footcandles in the large space between each lamp. Early comments from producers have indicated their birds are more evenly spaced through all areas of the barn, which results in a more relaxed growing environment. In addition, if a barn loses one large HPS lamp, a significant amount of barn space consequently becomes underlit. Now, if a smaller LED lamp fails (though none have to date), a smaller area of the barn is affected. This benefit is especially important for those lights over barn feed lines. If feed lines are not properly lit, birds will not see - or as aggressively pursue - food in that area, causing crowding in other areas of the barn/feed line which can harm bird welfare.

Timelines, communication and availability are key for purchase and installation decisions.

The early stages of the pilot project have revealed the necessity for all parties involved in the poultry lighting upgrade supply chain to be flexible and fast moving in regards to the light purchase and installation decision making process. Producers generally have about one to two weeks of barn downtime between the period when a full grown flock is sold and the new flock of birds is brought in to restart the growing cycle. The producer will utilize this down period to perform routine maintenance on their barns, clean them out, and make any necessary upgrades. Most often, this period will also be utilized to make any lighting upgrades, as well.

As such, if a producer decides to make a lighting upgrade as a down period nears, the product must be readily available, or the producer may be forced to wait on such an upgrade until the next production cycle ends. Product vendors, installers, and utilities attempting to design and implement rebate programs must work to provide sufficient information to the producer well ahead of the time for making a decision, and be ready to provide the product or service in a quick and efficient manner. While production cycles vary for each individual producer, a related stakeholder would do well to stay in touch with farmers and work to communicate about when a potential upgrade might work best. Then, the stakeholder can be prepared on their end to move on a project with a potentially limited implementation time frame.

Of course, in a perfect world, a producer would plan these upgrades well in advance of the down period, so all of the logistics could be worked out ahead of time. For some operations, this is the case. However, farms and farmers do not always have time in their full schedules to plan upgrades weeks or months in advance. Farms do not often have operations staff dedicated to facilities management. Indeed, farmers are required to be monitoring facilities, managing daily farm operations, and taking care of all other aspects of these highly intricate businesses. As such, projects such as lighting upgrades are often done when an opportune time presents itself, and must be accomplished in that small window.

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¹³ This benefit can of course be observed in other smaller lighting applications such as CFLs or incandescents, as well. However, incandescents are highly inefficient, and CFLs do not respond well to dimming. Dimming light levels, though, is an important aspect of most production lighting systems. As a result, producers will simply turn off lamps in barns with CFLs to achieve lower light levels in barns, resulting in the 'hot spot' effect previously

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